NPOESS PRECISION ORBIT DETERMINATION (POD) USING GPS AND SATELLITE LASER RANGING (SLR) DATA

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The National Polar-orbiting Operational Environment Satellite System (NPOESS) is a satellite system used to monitor global environmental conditions, and collect and disseminate data related to weather, atmosphere, oceans, land and near-space environment. The NPOESS mission is scheduled for first launch in late 2009. The 1730 Local Time of Ascending Node (LTAN) orbit satellite will feature a radar altimeter similar to that used on Jason-1, which is used to measure sea surface topography to an accuracy of 4.2 cm. The current NPOESS measurement precision requirement on sea surface topography is 3 cm. A recent study by Zelensky, et al. suggested the NPOESS radial orbit to be determined with an accuracy of 2 cm to meet the sea surface topography measurement accuracy requirement[4]. This paper presents an in-depth simulation NPOESS POD study that attempts to achieve the 2 cm radial orbit accuracy and validate the radial orbit accuracy. Double-differenced GPS dual-frequency carrier phase data is the primary tracking data for the NPOESS POD. Ground-based SLR data is a supplemental data source for POD and is also used for POD validation.

The fidelity of POD simulation depends on the fidelity of the employed dynamic and measurement model errors. This paper uses an error model that is derived from the models originally developed to predict orbit accuracy for TOPEX/Poseidon and GeoSat Follow-On Missions. These models were implemented by Rim, et al. for preliminary work on the ICESat mission[5]. The geopotential errors are created by employing the JGM-3 gravity model for data generation, and a JGM-3 clone model, where the JGM-3 solution covariance is mapped to the JGM-3 model coefficients, for data processing. One of the dominant non-gravitational errors is atmospheric drag model error. To simulate the atmospheric drag error, the NRLMSISE-00 (MSIS)[6] atmosphere density model is used for data generation, and the DTM[7] model is used during data processing.

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Rim, et al. compared three POD techniques that use GPS-based POD for ICESat: a dynamic approach, a reduced-dynamic approach, and a kinematic approach[8]. The dynamic approach fully utilizes the dynamic information and is limited by the dynamic model accuracy. The reduced-dynamics approach uses both geometric and dynamic information, assigns weights to their relative strength, and solves for local geometric corrections using a process noise model to absorb dynamic model errors. This approach requires continuous GPS tracking data. The kinematic approach uses measurement information only and does not require any dynamic description. This approach depends significantly on the quality and geometry of GPS data: the number of on-board GPS receiver channels, the direction of GPS signals, and GPS orbit accuracy. Rim, et al. showed that simulation results by these three approaches produced comparable ICESat orbit accuracy. This paper considers the dynamic approach, a historically dominant approach to low-Earth POD, for the NPOESS POD. The dynamic approach has its heritage from the GPS flight experiment on TOPEX/Poseidon[9]. By post-processing the continuous, global, and high-precision GPS tracking data collected by the on-board and ground-based receivers, the dynamics approach can tune dynamic model parameters – especially geopotential parameters – to reduce the effects of dynamic model errors in the gravity model. The epoch-state batch filter is used to dynamically map all data to an initial epoch, and processed simultaneously. By adjusting the drag coefficient over selected sub-arc lengths during data processing, some of the additional dynamic model errors can be absorbed. The resulting radial orbit accuracy will be accessed by analyzing the data residual, orbit overlap statistics, and the SLR residuals. The radial orbit accuracy will be validated by analyzing the SLR data residuals. The effect of solar radiation pressure on the orbit accuracy is also evaluated.

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